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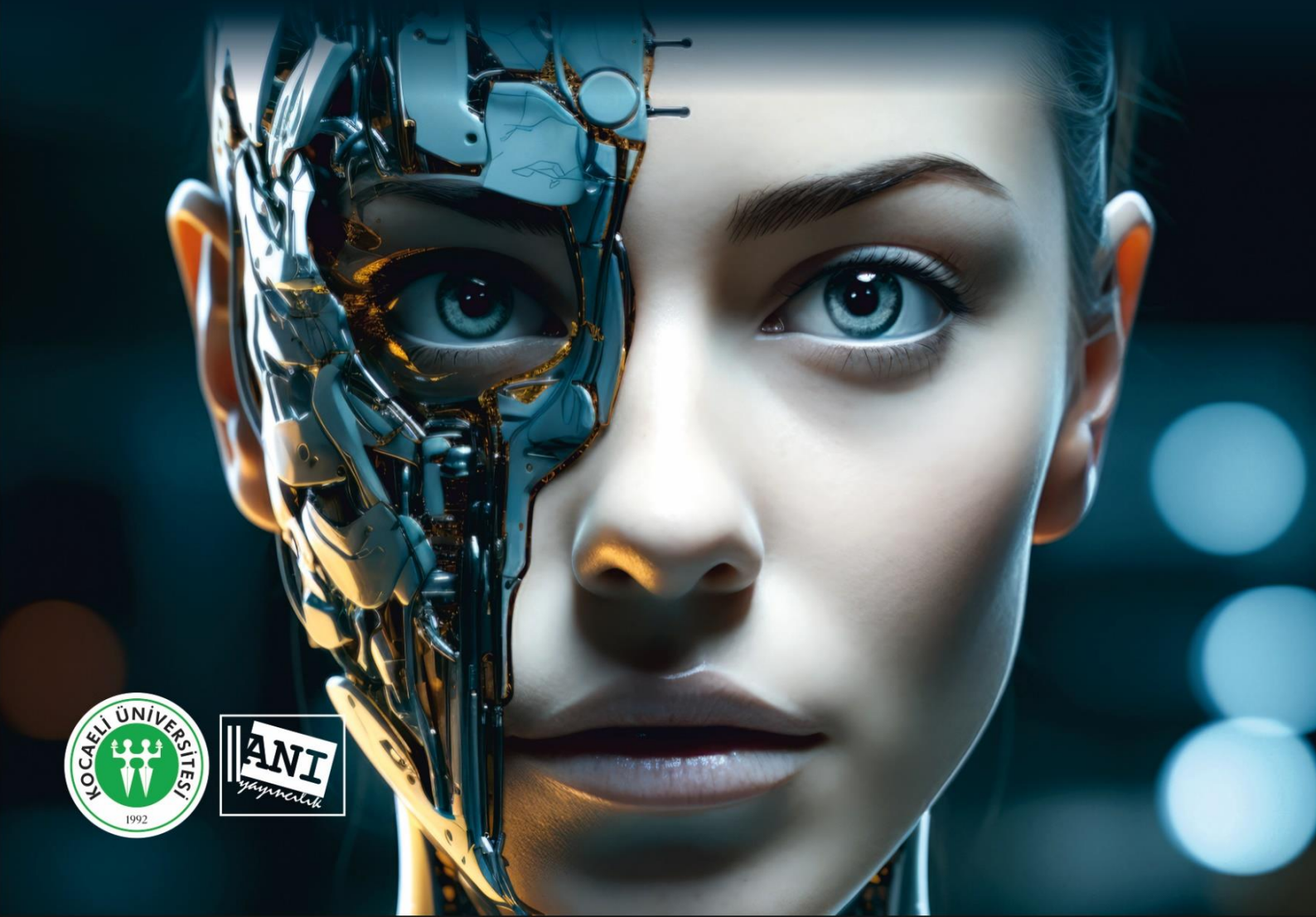

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Main Theme

"Designing the Future: Changing Paradigms and Transhumanism with Artificial Intelligence in Education"

Sub-Themes

- Academic freedom, autonomy, and social responsibility in education
- Artificial intelligence and educational applications
- Augmented reality applications
- Barriers to learning
- Blended learning
- Computer-assisted measurement and evaluation
- Core skill sets for students and teachers
- Design of school buildings in the future
- Designing and delivering a digital strategy
- Digital competence
- Digital parenting
- Distance Education
- Earthquake Education
- Post Earthquake Trauma Training
- Earthquake and Effective Psychosocial Intervention Methods
- Earthquake and Trauma
- The Impact of Earthquakes on School Staff
- Education and society
- Education for healthy living and healthy communities
- Education for a sustainable life
- Education in the digital age: Primary, secondary, high school, higher education, and application examples
- Educational leadership in the digital age
- Effects of regional differences on education
- Equity, Diversity, and Inclusion Related to Marginalized Groups
- Emergency Management at Schools
- Evidence-Based School Counseling Services for Refugees and Marginalized Groups
- Globalisation and Education
- Higher education
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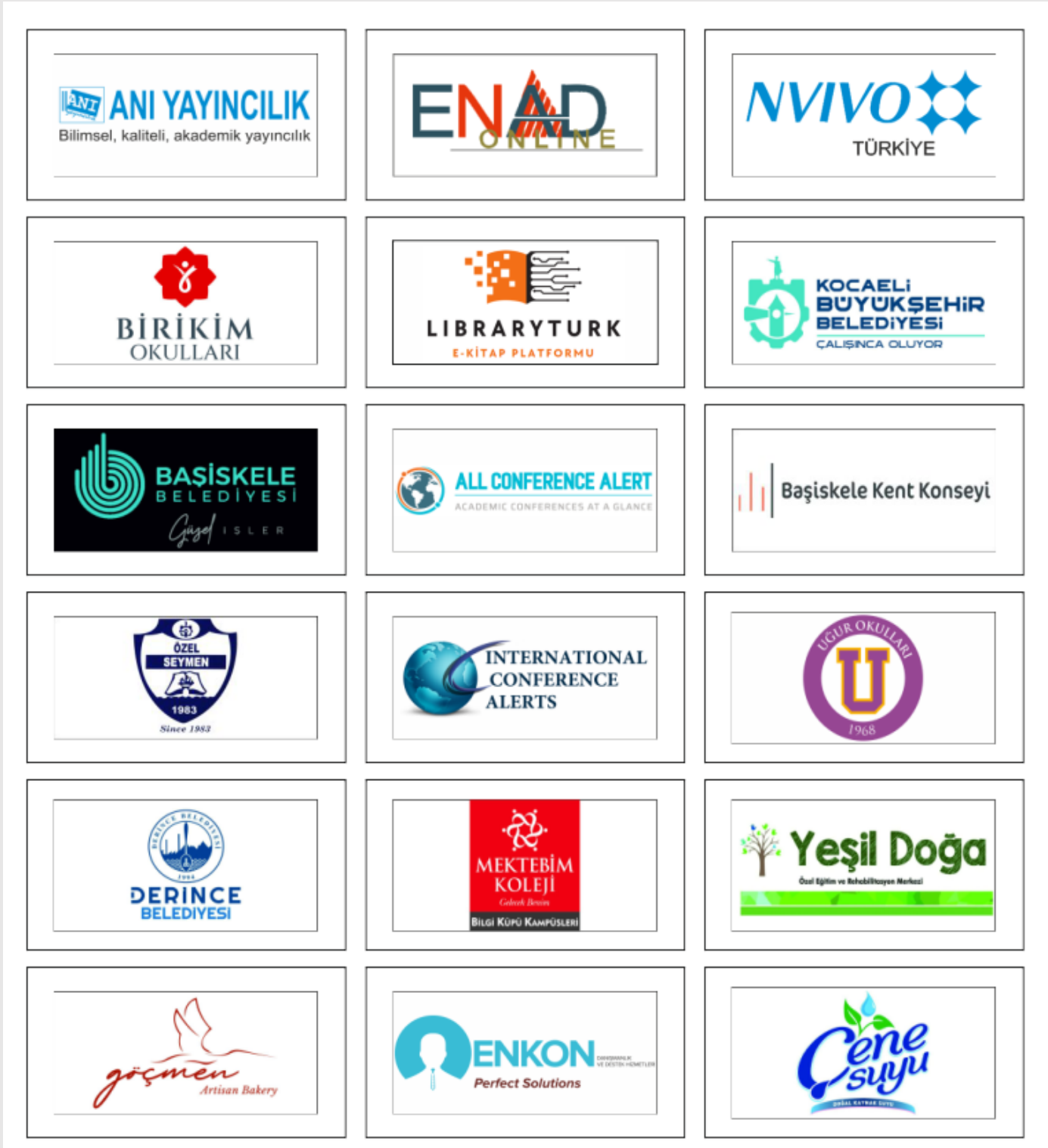

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Investigating the Change of Pre-service Middle School Mathematics Teachers' Conceptualization of Algebraic Thinking

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Abstract

Algebra holds an important role in school mathematics, and teachers must recognize the broad range of algebraic ideas and develop a deep understanding of these concepts to teach algebra conceptually. This study aims to investigate two pre-service middle school mathematics teachers' (PSTs) conceptualization of algebraic thinking before and after participating in an intervention designed to support PSTs' algebraic thinking and noticing of student algebraic thinking using a Seeds of Algebraic Thinking (AT) Perspective. This study was conducted as part of a mathematics methods course offered for middle school mathematics teachers in the 2023-2024 academic year at a large public university in the United States. To investigate PSTs' initial conceptions of algebraic thinking as well as the change in their conceptions, interviews were administered before and after the intervention. The data sources for this study were the pre- and post-interviews of the two participating PSTs. The data were analyzed qualitatively. The findings showed that both PSTs widened their algebraic thinking conceptualization after they participated in the video-based intervention designed using seeds of AT perspective. The findings showed that the intervention fostered their algebraic thinking conceptualization in different ways. After the intervention, PST1 broadened her conceptions to include other formal algebraic thinking ideas, such as generalizing and formalizing, using algebra as a tool, and reasoning about and with representations; PST2 deepened her conceptualization in terms of "early" algebraic thinking, such as balance, comparison, and proportionality.

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Keywords: *Mathematics education, Algebra, Seeds of algebraic thinking, Video-based intervention*

Introduction

Algebra holds an important role in school mathematics. Learning algebra is critically important for students around the world today; however, it has historically been challenging for students. Traditional algebra classes tend to center the manipulation of symbols, with a focus on variables and solving equations (Stephens, 2008; Walkoe, 2010). Research has indicated that some mathematics teachers' (and pre-service mathematics teachers') perceptions of algebra are limited by a traditional viewpoint, particularly, the use of symbols and manipulations of symbols (Asquith et al., 2005; Stephens, 2008). However, algebra is much more than symbol manipulation.

The literature provides a variety of definitions of algebra, which include generalized arithmetic, though there is no unique definition of algebra (Usiskin, 1988). Usiskin (1988) claimed that there are different conceptions of algebra, related to other uses of variables such as a study of relationships, structure, or the study of procedures for solving certain problems. Kieran (2004) proposed three forms of algebraic activities the generational, the transformational, and the global-meta level activity. Kaput (2008, p.11) argues two core aspects of algebra: "Algebra as systematically symbolizing generalizations of regularities and constraints (Core Aspect A)" and "algebra as syntactically guided reasoning and actions on generalizations expressed in conventional symbol systems (Core Aspect B)". These different definitions of algebra and algebraic reasoning provide a broad perspective on the scope of algebraic thinking and indicate that algebra is a way of thinking beyond the manipulation of symbols. Many of these definitions were described and consolidated into an Algebraic Thinking Framework that illustrated the types of algebraic thinking that could be visible to teachers in the classroom (Walkoe, 2013). These perspectives commonly show that algebraic thinking includes using symbols, generalizing, analyzing relationships between quantities, examining changes, problem-solving, and functional thinking.

If one of the fundamental issues is fostering students' algebraic thinking/reasoning with a focus on understanding patterns, relations and functions as well as representing and analyzing, in elementary and middle school mathematics curricula (National Council of Teachers of Mathematics

[NCTM], 2000), teachers must recognize the broad range of algebraic ideas and develop a deep understanding of these concepts to teach algebra conceptually. Teachers' understanding and conceptualizations of mathematics affect their pedagogical decisions and teaching practices (Stephens, 2008). Stump and Bishop (2002) emphasized the importance of pre-service teachers understanding algebra as a way of thinking to be able to promote algebraic thinking effectively in their classrooms. However, the findings of several studies, which investigated teachers' and mathematics teachers' algebra or algebraic thinking conceptions (e.g., Asquith et al., 2005; Stephens, 2008; Walkoe, 2010), showed that teachers' and pre-service teachers' conceptions were mostly narrow. For example, Asquith et al. (2005) investigated ten middle school teachers' algebraic thinking perceptions through an hour-long videotaped interview. They offered three tasks to teachers to engage in algebraic thinking and asked them to identify the tasks' algebraic thinking potential for students, to predict students' responses/strategies to these tasks and to describe the algebraic properties of students' written work that they observed. Their findings revealed that while some of the middle school teachers had multiple perceptions of algebraic thinking and recognized the different aspects of algebraic thinking in students' work, several teachers' algebraic thinking perceptions emphasized the use of variables. Stephens (2008) examined thirty preservice elementary teachers' conceptions of algebra through the question "How would you describe algebra to someone who has never heard of it before?" and engaging in a semi-structural interview in the methods course. Stephens (2008) used five mathematics tasks, e.g., open box task, 37+54=□+55, as well as student work on these tasks during the interviews and asked the participants whether these were algebra problems or not. Based on both questions and interview data, the findings showed that preservice teachers had a narrow conception of algebra, and their conceptions were mostly dominated by symbols and symbol manipulation. The findings also indicated that the pre-service teachers classified the tasks as algebra or algebra based on the absence of a variable or a letter.

These studies indicate that teachers' algebraic thinking conceptualization should be fostered, and their emphasis should be shifted away from symbolic manipulations. Stump and Bishop (2002) pointed out that organizing experiences for pre-service teachers to broaden their vision of algebra should be an important goal of mathematics teacher educators. They stated that when pre-service teachers have a broad vision of algebra, they can effectively promote elementary and middle school children's algebraic reasoning. Therefore, conducting research in which preservice mathematics teachers' conceptions of algebra and algebraic thinking are investigated and improved through the specially designed intervention, is crucial.

This study utilizes the seeds of the algebraic thinking perspective (Levin & Walkoe, 2022; Walkoe & Levin, 2020) to help pre-service teachers broaden what they consider to be algebraic thinking through an intervention. This study aims to investigate two pre-service middle school mathematics teacher's (PSTs) conceptualization of algebraic thinking before and after participating in an intervention designed to support PSTs' algebraic thinking and noticing of student algebraic thinking using seeds of AT perspective (e.g., Levin & Walkoe, 2022). The intervention focused on pre-service teachers' attention to children's formal and pre-formal-nascent algebraic thinking and supporting their noticing of student multimodal algebraic thinking by using new video annotation tools.

Seeds of Algebraic Thinking (AT) Perspectives

Seeds of AT is a novel theoretical idea regarding algebraic thinking based on children's early experience. Walkoe and Levin (2020) explained that seeds of algebraic thinking are productive cognitive resources of algebraic thinking that come from children's pre-instructional experiences, which have a role in their later learning of mathematics. The researchers stated three main properties of seeds of algebraic thinking: i) formed in early experience, ii) small in grain size, and iii) contextually recognized, that is, they are not naturally correct or incorrect. Levin and Walkoe (2022) expressed that "algebra-relevant knowledge is a large knowledge system composed of cognitive resources gained through experience. We term these resources seeds of algebraic thinking (p.4)".

Walkie and Levin (2020) include balance as an example of the seeds of algebraic thinking, or subconceptual knowledge which children gain as they play with toys. "Co-variation, in-betweenness, closing-in or order matters" are some other examples. These ideas can be reencountered later in children's lives. Levin and Walkoe (2022) propose that teachers' awareness of the seeds of algebraic thinking perspective helps them to shift their engagement in terms of attending and responding to students' early algebraic thinking. Seeds of algebraic thinking perspective have potential for teachers to change their focus from fully-formed conceptions to nascent student ideas (Levin & Walkoe, 2022).

Method

Research Design

This study utilized a qualitative case study to examine PSTs algebraic thinking conceptualization before and after participating in an intervention. PSTs algebraic thinking conceptualization examined under the instructional intervention designed constitutes the case.

Participants of the Study

This study was conducted as part of a mathematics methods course offered for middle school mathematics teachers in the 2023-2024 academic year at a large public university in the United States. Six PSTs, in their third year of the program, were enrolled in the course. One of the goals of the methods course was to support PSTs' algebraic thinking and their noticing of students' thinking about early algebra using seeds

of AT perspective (e.g., Walkoe & Levin, 2020). To address this goal, PSTs attended an intervention including six video clubs (Sherin & van Es, 2009) as part of their coursework. This study focused on the two of six PSTs who volunteered for the interview before and after the intervention.

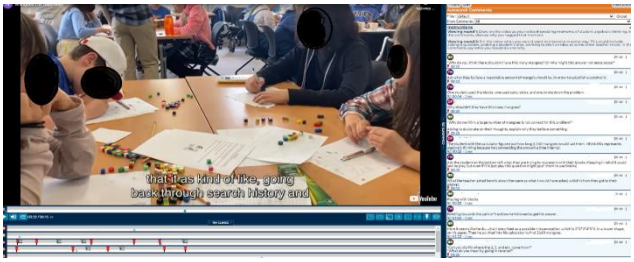
The Design/Intervention and Data Collection

To investigate PSTs' initial conceptions of algebraic thinking as well as the change in their conceptions, interviews were administered before and after the intervention. The individual pre-interviews were conducted with two volunteer PTSs via Zoom and recorded with their permission.

As part of the video club professional development, PSTs were briefly introduced to the seeds of algebraic thinking as well as the algebraic thinking framework developed by Walkoe (2015). In the context of each video club session, PSTs initially watched short video clips (4-8 min) through an online video tagging tool where they could observe students' algebraic thinking and comment on moments when they noticed students using algebra (see Figure 1). PSTs were prompted to tag moments in the videos while responding to the prompt, "What interesting algebraic thinking do you notice?". During the intervention, they attended six video club sessions.

Figure 1

Online Tagging Tool in Which PSTs Tagged Several Moments and Commented



When they finished annotating each video, the PSTs and the instructor discussed the nature of students' algebraic thinking and the seeds of algebraic thinking in the video clubs. The course instructor facilitated the video club discussions. During each video club discussion, the facilitator pushed PSTs to explain and clarify their ideas about student thinking by asking questions and prompts such as "What interesting algebraic thinking did you notice?", "That's an interesting point. Did anyone else notice that part?", "What do other people think of that idea?" "Do you agree? What did the student do, how did that surprise you at all?".

After the video club sessions concluded, the individual post-interviews were conducted with the same two PTSs via Zoom and recorded with their permission. Pre-and post-interviews included the same questions and multiple parts. The first part comprised several verbal questions about algebraic thinking, e.g., "Can you give me an example, in which students were thinking algebraically?". The second part involved five mathematics questions, and the participants were asked if they considered these questions to be "algebraic or not". The third part included possible student solutions to the questions asked in the second part and PSTs were asked if the students used algebra or not in their solutions. Each interview took around 35 minutes.

Data Analysis

The data sources for this study were the pre- and post-interviews of the two participating PSTs. The data were analyzed qualitatively through algebraic thinking framework (ATF) developed by Walkoe (2015, p.528) that included six categories of algebraic thinking that might be visible to teachers, "manipulation of symbols and procedures (MoS&P), exploring relationships (ER), generalizing and formalizing (G&F), using algebra as a tool (UAaT), reasoning about and with representations (Ra&wR), and connecting representations (CR)" and through seeds of algebraic thinking that involved balance (e.g., Levin & Walkoe, 2022; Walkoe & Levin, 2020). Furthermore, some codes, e.g., number relationships (NR), comparing (CMP), working backward (WB), ratio and proportioning were data grounded.

Results

The pre-interviews showed that both PSTs had different algebraic thinking conceptualizations before the intervention. As presented in Table 1, both PSTs' algebraic thinking conceptualization included more than one type of algebraic thinking. PST1's conception included manipulation of symbols and procedures, exploring relationships and generalizing and formalizing ideas; however, it was dominated by symbol manipulation and procedures, particularly, finding the unknown.

Table 1

The PSTs' Algebraic Thinking Conceptualization in the Pre-Interview

Data		MoS&P	ER	G&F	UAaT	Ra&wR	CR	Balance	NR	CMP	WB	Other: Ratio; Proportioning
Tasks	Verbal Questions	PST1		PST2				PST2	PST2			
	Q1	PST1						PST2	PST2			PST2
	Q2	PST1						PST2	PST2			
	Q3	PST1		PST2								
	Q4	PST1	PST2	PST2		PST2						
	Q5		PST2			PST2						
Students' solutions	Q1		PST1 PST2						PST2			
	Q2	PST1 PST2	PST1 PST2									
	Q3			PST1 PST2								
	Q4	PST1	PST2									
	Q5					PST2						

PST1 described algebra as "a form of mathematics to solve for the unknown" as she discussed students' algebraic thinking by giving an example, "$6x = 30$". Furthermore, PST1 categorized the question (Q1), presented in Figure 2, as algebraic by expressing her ideas based on the symbol manipulations and procedure.

Figure 2

The mathematical tasks (Q1) in pre-interview (Stephens, 2008)

Q1: What number goes in the _?, 37+54=___+55

The PST1's explanation is presented below.

I would say this is an algebraic problem because it does say what number goes on the blank which is finding the unknown. So, you have to figure out what goes into the blank and to do that you would have to, you know, add on one side and since you don't know it in the other things you subtract that to do that, you can find the unknown.

Moreover, PST1 categorized the problem (Q5), presented in Figure 3, as not algebraic by pointing out that there was no specific number to find.

I would not say that is algebraic. The only reason why is because we are not trying to find any specific number. When I try to find an unknown, it tells us that we should schedule a graph that shows Lisa's lemonade stand per day between April and October and so when we do that, there are really no numbers, or they don't give us any numbers that are involved.

This problem includes algebraic ideas such as analyzing changes, looking for relationships between variables, and creating graphs to represent relationships. By working through this problem, students are expected to analyze the

change by examining the relationship between variables and then represent the relationship graphically (Billing & Lakatos, 2003). However, as shown in PST1's response, her algebraic focus was mostly on procedures to find the unknown.

Figure 3

The mathematical tasks (Q5) in pre-interview (Billings & Lakatos, 2003, p.457)

Q5: "Lisa opened her Lemonade stand on the first day of May. Her average number of glasses sold per day rose at a steady rate between May and June and remained constant until mid-August. The average number of sales per day decreased through late August until the stand closed about mid-September. Sketch a graph of what Lisa's average lemonade sales per day probably looked like between April and October of her first year in business.

In contrast to PST1, PST2's conception included broader algebraic thinking categories and was dominated by exploring relationships, generalizing and formalizing and reasoning about and with representations (see Table 1). Furthermore, PST2's conceptions comprised several general (seeds of algebraic thinking) and formal knowledge resources of algebraic thinking such as number relationship and balance. PST2 described "algebra as being a form of thinking, that I think in this case the specific question a form of thinking in relationships to numbers so being able to compare, and to relate and figure out the size of the numbers and different forms*".* When she was asked to give an example in which students were thinking algebraically, she expressed an example of budget as presented below.

I see that what students think algebraically is nowadays everything I see more with money, when students' kinds of seem to budget themselves, so sometimes students say that they want to buy either a game, toy or they want to buy a certain food know how much they have, they don't know how much something costs, so I see students sometimes algebraic thinking to think how much money they should have or how much money they believe it should be before they could buy something. I also see algebraic thinking with the use some space because certain students have either backpacks or desks, will they know how much staff to inside of it and preplanned depending on how much space they know they have to buy a certain amount of items that they know will fit on it. It seems like they do this balancing of numbers and objects already in their mind, even if it is not exactly an algebraic equation, it is a form of physical equation in their head to see constraint which is a limit, and they try to use their resources to have reached that limit…so it seems that as they have already had an understanding when an objective purchased the money that that they have goes down, so they see the relationship between what they want and what they already have and how one effects the other in terms of money and numbers.

As shown in PST2's response, she emphasized students' potential algebraic thinking ways by providing an example. Instead of focusing on students' formulating and solving an equation, PST2 explained how students make related and balance the numbers in their minds when they want to buy something. PST2 additionally categorized question (Q2), presented in Figure 4, as algebraic by pointing out the idea of balance on both sides of the equation. As shown in PST2's response below, instead of focusing on the algebraic procedure in this question, PST2 emphasized the balance.

Figure 4

The mathematical tasks (Q2) in pre-interview (Stephens, 2008)

Q2: The solution to the equation 2n+15=31 is n=8. What is the solution to the equation 2n+15-9=31-9.

PTS2's expressed her ideas as presented below:

I also think that this is an algebraic problem because it kind of pushes student thinking towards solving the equation in a non-traditional way, so it is just solving for everything on one side and something for everything on the other side and subtracting like I did in the previous equation. It kind of pushes students to think to whether we already have an initial equation with this answer. However, these changes are affected, if the change is also made on both sides. So, it's an algebraic way of thinking about how this similar change of both sides gonna affect the balance. Or if it one affected also the variable would be the same. So this is what I think is an algebraic equation.

As presented in Table 2, post-interviews revealed that PST1 improved algebraic thinking conceptualizations, by expanding her focus to include generalization, comparison, and exploring relationships. Differently, PST2 noticed more "early or nascent" algebraic thinking such as balance, comparison, and proportionality, and widened her conceptualization in this respect. That is, PST2's algebraic thinking conceptualization broadened more on knowledge resources of algebraic thinking. Furthermore, comparison was an idea that emerged in both PSTs' algebraic thinking conceptions in the post-interview.

As seen in Table 2, in the post-interview, PST1 included reasoning about and with representations when she was talking about Q4 and the students' solutions for Q4 and Q5. Even though she was still talking about finding the unknown for the student's solution of Q4 in Figure 5, she expanded her algebraic thinking conception and interpreted the task in terms of representation.

I said it would be algebraic because we are still finding the unknown for the rest of it. I think this would be algebraic because it is talking about the slope and they said that the increases by two, so the slopes must be 2. I think this is algebraic just because like when you see how she did the table it correlates the how the graph is shown and this is just like another representation of how she can find the slope with just the numbers specifically.

Figure 5

One of the Student Solutions for Q4

Student Solution: Students draw a table,

x	y
0	0
1	2
2	4
3	6
4	8
.	.
.	.
.	.

and writes, says the output numbers increase by the same value each time, they increase by 2, so the slope of the graph is 2.

Furthermore, while PST1's focus was the manipulation of symbols and procedures in the pre-interview for Q1, in the post-interview, she interpreted the question by pointing out the comparing idea as presented below.

So, I said that I think this is algebraic because we are finding the unknown here. And the unknown would be 36. This is what number goes in the blank, so we obviously do not know what it is, but we are comparing both sides of the equation and when we do that the number in the blank will be 36

"Comparing" is a possible knowledge resource of algebra and it constitutes a basis for understanding the concept of equality and equal sign. Comparing ideas prompts algebraic reasoning in this question and provides a robust understanding of the structure of the equal sign. As shown in PST1's expression, she shifted her initial focus from telling the procedure to explaining the relationship between the right and left sides of the equation by comparing.

Table 2

The PSTs' Algebraic Thinking Conceptualization in the Post-Interviews

Data		MoS&P	ER	G&F	UAaT	Ra&wR	CR	Balance	NR	CMP	WB	Other: Ratio; Proportioning
Verbal Questions		PST1		PST1				PST2	PST2	PST1		PST2
Tasks	Q1	PST1						PST2		PST1		PST2
	Q2		PST2		PST1			PST2	PST2			
	Q3	PST1			PST2							
	Q4	PST1	PST2			PST1						
	Q5		PST1 PST2			PST2						
Students' solutions	Q1		PST1					PST2		PST2		
	Q2		PST1		PST1					PST2		
	Q3			PST1							PST2	
	Q4	PST1 PST2		PST1		PST1 PST2						
	Q5					PST1						

Like PST1's comparing idea, one of the ideas distinctively recognized by PST2 as a knowledge resource of algebra was balance and the number relationship (Levin & Walkoe, 2022). PST2 expressed that "thinking algebraically to me means, for example, being able to balance things, understanding the concept of numbers, understanding the importance of the relationship of numbers". She also explained for Q1 in Figure 2 "I do believe that is algebraic, the equal sign in the question with the two sides of really reminds me of a balance. So, understanding the concept of balancing stuff on both sides of the equation…". Furthermore, PST2 expressed that Q3 (see Figure 4) encompasses algebraic thinking because of the relationship between two equations, the balance idea and the relationship between numbers in the equations. As presented below, PST2 offered a comprehensive justification and explained how students' algebraic thinking helps them to solve the question more simply.

I feel also like this question encompasses algebraic thinking because they need to understand the relationship between the two equations. The first equation is slightly altered to the first equation. So being able to form that idea of the relationship between the two equations and understanding how the equations are similar and how the equations are different for example in the second one -9 is an item on both sides and understanding that because I don't have both sides, it can be canceled out. So again, understanding this concept of balance and understanding how the numbers in traffic each other. I feel like would require algebraic thinking in order to do I feel like if a student does not corporate algebraic thinking they will realize that those numbers can be canceled out a student who might not be too familiar with algebraic thinking, might just solve in the standard form and completely ignore the beginning of the problem, in order to solve more simpler way, I feel like it would require algebraic thinking.

The data suggests that the intervention supported the change of both PSTs' algebraic thinking conceptions in different ways. At the end of the intervention, PST1 broadened her algebraic thinking conception in terms of fully formed conceptions, and PST2 shifted her focus more on the pre-formal algebraic thinking of students. The data explored a variety of examples which showed PSTs' conceptions of algebraic thinking more broadly.

Discussion

The comparison of PSTs' responses to the questions in pre- and post-interviews showed that both PSTs widened their algebraic thinking conceptualization after they attended the video-based intervention designed using seeds of AT perspective. However, the findings revealed that the intervention fostered their algebraic thinking conceptualization in different ways. Prior to the intervention, PST1 focused on mostly finding unknowns as a manipulation of symbols and procedures, and then after the intervention she broadened her conceptions to include other formal algebraic thinking ideas such as generalizing and formalizing, using algebra as a tool, reasoning about and with representations. In contrast, after the intervention, PST2 deepened her conceptualization in terms of "early" algebraic thinking such as balance, comparison, and proportionality. One of the reasons why PSTs AT conceptualization changed in different ways can possibly be related to their prior conceptions. The data showed that PST2 had a wider and more diverse conceptualization than PST1 before the intervention. Therefore, the intervention might have helped PST2 take a new perspective on algebraic thinking, understand the reasons for the seeds of algebraic thinking, and extend her algebraic thinking conceptions in terms of pre-conceptual algebraic ideas.

In addition, specific theoretical and practical experiences involved in the intervention could have helped PSTs strengthen their understanding of what constitutes algebraic thinking. First, at the beginning of the video club sessions, all PSTs enrolled in the course were given a short introduction to the seeds of AT perspective, as well as an algebraic thinking framework which could articulate PSTs' discussions about algebraic thinking (Walkoe, 2015). Second, while they were tagging students' algebraic thinking, PSTs could closely observe and attend to the students' thinking in both non-algebraic and algebraic contexts as well as notice potentially algebraic moments. Finally, in the video club discussions, all PSTs discussed the ideas concerning seeds of algebra like balance, comparing, representation, order of operations, proportioning, replacement and greater or less, with the help of the facilitator. That is, through the video clubs based on seeds of AT perspective, PSTs found an opportunity to notice and discuss on small grained algebraic ideas of students' thinking rather than looking only for fully formed algebraic ideas, and they could make connections between these pre-conceptual and formal conceptual algebraic ideas. PSTs' attending to, interpreting and discussing students' algebraic thinking deeply may have an impact on PSTs to broaden their own algebraic thinking conceptions.

Conclusion

Video clubs are powerful tools to develop teachers' teaching and noticing skills (Borko et al., 2008; Sherin & van Es, 2009), and much research shows that video-based intervention (PD) supports PSTs' noticing of student thinking in the different domains (e.g., Girit-Yıldız, Osmanoglu, & Alayli, 2023; Tekkumru-Kisa, Stein, & Coker, 2018; Walkoe, 2015). Furthermore, Levin and Walkoe (2022) hypothesize that teachers' awareness of seeds of algebraic thinking may shift their engagement with students' thinking in the classrooms. In this paper, we illustrated how a video club design based on seeds of AT perspective can also support the improvement of PSTs' algebraic thinking conceptions by providing a rich theoretical and practical environment for PSTs to understand students' formal and early algebraic thinking.

Recommendations

The findings of the study were limited to only two PSTs enrolled in the intervention and further research should consider examining the change of all PSTs' algebraic thinking conceptions enrolled in the intervention.

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